

MULTIMEDIA



UNIVERSITY

STUDENT ID NO

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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

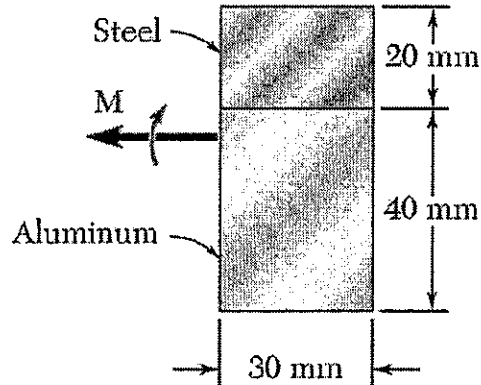
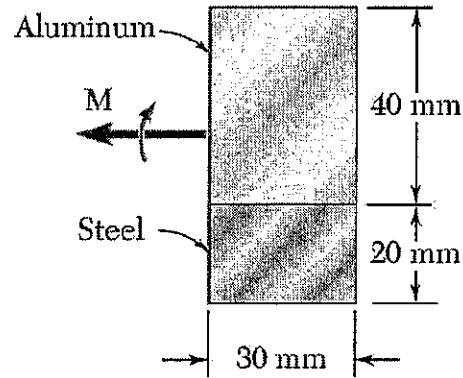
DME5096 – STRENGTH OF MATERIALS

(Diploma in Mechanical Engineering)

12 AUGUST 2022
9:00 a.m. – 11:00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages with 4 Questions excluding cover page.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1 (25 marks)**Figure Q1a****Figure Q1b**

A steel bar and an aluminum bar are bonded together to form the composite beam shown in Figure Q1a. The modulus of elasticity for aluminum is 70 GPa and for steel is 210 GPa. Knowing that the beam is bent about a horizontal axis by a couple of moment $M = 1500$ N.m, determine the maximum stress in

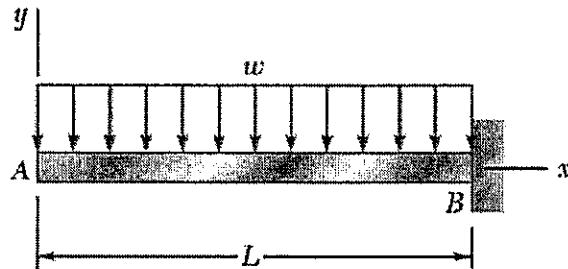
- (a) the aluminum, [10 marks]
- (b) the steel. [4 marks]

If the orientation of the composite is changed as shown in Figure Q1b, then determine the maximum stress in

- (c) the aluminum, [4 marks]
- (d) the steel. [4 marks]

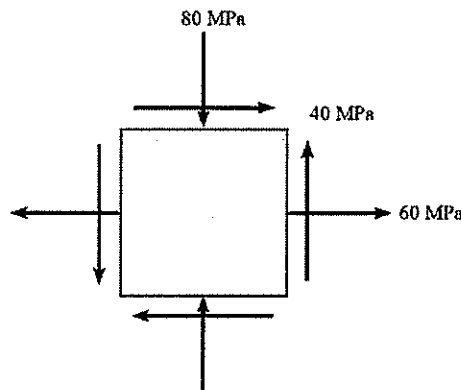
- (e) Which orientation is suitable for the given M ? Explain your answer. (Hint: The allowable compressive stress is about 50% higher than allowable tensile stress. The allowable stresses for steel are about 2.5 times greater than the aluminum.) [3 marks]

Continued ...

Question 2 (25 marks)**Figure Q2**

For the loading shown in Figure Q2, determine

- (a) the equation of the elastic curve for the cantilever beam AB, [11 marks]
- (b) the deflection at the free end, [4 marks]
- (c) the slope at the free end in term of E , I , w and L . [4 marks]
- (d) Use superposition method to verify the answers for (a), (b) and (c). [6 marks]

Question 3 (25 marks)

For (

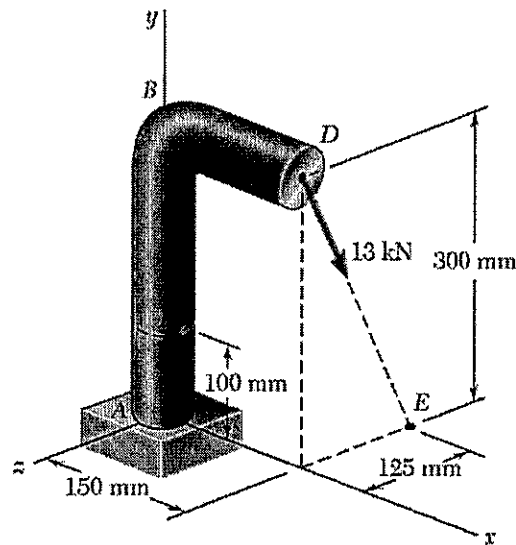
Figure Q3

The state of plane stress at a point is represented by the element shown in Figure Q3. Determine

- (a) the principal planes and corresponding stresses, [11 marks]
- (b) the maximum in-plane shear stress and its plane and the associated average normal stress, [3 marks]
- (c) the state of stress on another element oriented at the same point, but 25° clockwise from the position shown. [11 marks]

(Construct a Mohr Circle first before showing your each solutions)

Continued ...

Question 4 (25 marks)**Figure Q4**

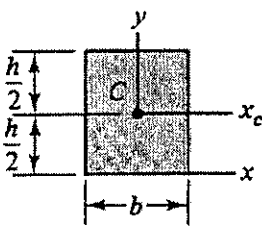
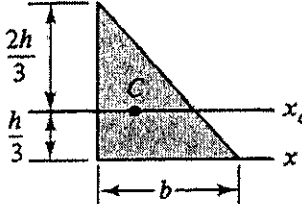
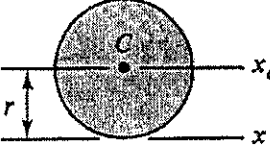
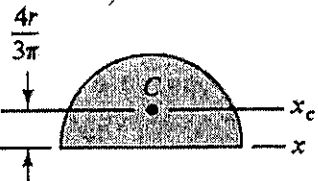
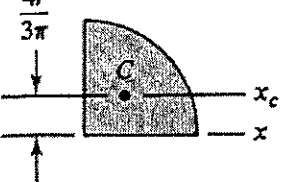
A 13-kN force is applied as shown to the 60-mm-diameter cast-iron post ABD as shown in Figure Q4. At point H , determine

- | | |
|--|------------|
| (a) the normal stress, | [11 marks] |
| (b) the shear stress, | [4 marks] |
| (c) the principal stresses and principal planes, | [8 marks] |
| (d) the maximum shearing stress. | [2 marks] |

Continued ...

Appendix A

Moments of Inertia of Simple Shapes

Shapes		I_x	I_{x_c}
Rectangle		$\frac{bh^3}{3}$	$\frac{bh^3}{12}$
Triangle		$\frac{bh^3}{12}$	$\frac{bh^3}{36}$
Circle		$\frac{5\pi r^4}{4}$	$\frac{\pi r^4}{4}$
Semicircle		$\frac{\pi r^4}{8}$	$0.0349\pi r^4$
Quarter-circle		$\frac{\pi r^4}{16}$	$0.01747\pi r^4$

Continued.....

Appendix B

TABLE G-1 DEFLECTIONS AND SLOPES OF CANTILEVER BEAMS

	v = deflection in the y direction (positive upward) $v' = dv/dx$ = slope of the deflection curve $\delta_B = -v(L)$ = deflection at end B of the beam (positive downward) $\theta_B = -v'(L)$ = angle of rotation at end B of the beam (positive clockwise) EI = constant
1	$v = -\frac{qx^2}{24EI}(6L^2 - 4Lx + x^2) \quad v' = -\frac{qx}{6EI}(3L^2 - 3Lx + x^2)$ $\delta_B = \frac{qL^4}{8EI} \quad \theta_B = \frac{qL^3}{6EI}$
4	$v = -\frac{Px^2}{6EI}(3L - x) \quad v' = -\frac{Px}{2EI}(2L - x)$ $\delta_B = \frac{PL^3}{3EI} \quad \theta_B = \frac{PL^2}{2EI}$
6	$v = \frac{M_0x^2}{2EI} \quad v' = \frac{M_0x}{EI}$ $\delta_B = \frac{M_0L^2}{2EI} \quad \theta_B = \frac{M_0L}{EI}$

TABLE G-2 DEFLECTIONS AND SLOPES OF SIMPLE BEAMS

$EI = \text{constant}$	v = deflection in the y direction (positive upward) $v' = dv/dx$ = slope of the deflection curve $\delta_C = -v(L/2)$ = deflection at midpoint C of the beam (positive downward) x_1 = distance from support A to point of maximum deflection $\delta_{\max} = -v_{\max}$ = maximum deflection (positive downward) $\theta_A = -v'(0)$ = angle of rotation at left-hand end of the beam (positive clockwise) $\theta_B = v'(L)$ = angle of rotation at right-hand end of the beam (positive counterclockwise)
1	$v = -\frac{qx}{24EI}(L^3 - 2Lx^2 + x^3)$ $v' = -\frac{q}{24EI}(L^3 - 6Lx^2 - 4x^3)$ $\delta_C = \delta_{\max} = \frac{5qL^4}{384EI} \quad \theta_A = \theta_B = \frac{qL^3}{24EI}$
4	$v = -\frac{Px}{48EI}(3L^2 - 4x^2) \quad v' = -\frac{P}{16EI}(L^2 - 4x^2) \quad \left(0 \leq x \leq \frac{L}{2}\right)$ $\delta_C = \delta_{\max} = \frac{PL^3}{48EI} \quad \theta_A = \theta_B = \frac{PL^2}{16EI}$
10	$v = \frac{M_0x}{2EI}(L - x) \quad v' = \frac{M_0}{2EI}(L - 2x)$ $\delta_C = \delta_{\max} = \frac{M_0L^2}{8EI} \quad \theta_A = \theta_B = \frac{M_0L}{2EI}$

Appendix C

Axial Loading

$$\delta = \frac{PL}{EA} \quad \varepsilon = \frac{\Delta L}{L_0} \quad \sigma = \frac{P}{A_0} \quad \frac{\Delta V}{V_0} = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

$$\varepsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)] \quad \varepsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_x + \sigma_z)] \quad \varepsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)]$$

Torsion

$$\tau = \frac{Tr}{J} \quad \Phi = \frac{TL}{JG} \quad \frac{T_1}{r_1} = \frac{T_2}{r_2} \quad \gamma = \frac{\rho\phi}{L} \quad r_1\omega_1 = r_2\omega_2 \quad P = T\omega$$

Polar moment of inertia of a circle of radius r

$$J = \frac{\pi}{2} r^4$$

Polar moment of inertia of a ring of inner radius r_2 and outer radius r_1

$$J = \frac{\pi}{2} r_1^4 - \frac{\pi}{2} r_2^4$$

Pure Bending and Transverse Loading

$$\sigma_x = -\frac{My}{I} \quad \sigma_{\max} = \frac{Mc}{I} = \frac{M}{S} \quad \varepsilon_x = -\frac{y}{\rho} \quad \tau = \frac{VQ}{It} \quad \tan \phi = \frac{I_z}{I_y} \tan \theta$$

$$I_{x'} = I_x + Ad^2$$

For circular shaft $\tau = \frac{VQ}{It}$, $\tau_{\max} = \frac{4V}{3A}$

Distance to center of geometry from the y -axis

$$\bar{y} = \frac{\sum yA}{\sum A}$$

Relations between bending moment M , shear force V , and intensity q of distributed load.

$$\frac{dV}{dx} = -q \quad \frac{dM}{dx} = V$$

End of Paper